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Title: A REVIEW- GRAVEL GERTIE FULL SCALE TESTS

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Introduction

The Gravel Gertie was designed as a space in which to perform what is generally conceded to be the most hazardous operation in the assembly of a nuclear explosive, the mating of the High Explosive (HE) and fissile material in the primary of the weapon. The target of the design was to have a space which, in case of an accidental explosion of the HE, would withstand the blast and gas pressure loads from the explosion, relieve the pressure produced by the explosion, and inhibit the release of particulate matter to the atmosphere.

The history of the design of the Gravel Gertie is somewhat murky, but it seems to have been developed in 1956 by the Pantex Operating Contractor, Mason and Hanger-Silas Mason Co., Inc. It is not known who the smart guy was that named the facility for a character in the Dick Tracy cartoons but as you will see, the name is well taken.

The heart of the Gravel Gertie is a round room with floors and wall sturdy enough to withstand the various loads that will be impressed on them and covered with a thick gravel roof suspended on a network of bridge cables. Staging areas are connected to the round room in all the Gravel Gerties constructed up to the present. Figure 1 is a plan of a DAF Gravel Gertie with its associated staging areas, service rooms and entrance airlocks. Figure 2 is an elevation, which shows the suspended ceiling. The original Gravel Gertie was designed to confine the explosion of 550 lb of TNT or 423 lb of PBX-9404 or similar HE. The round room has a diameter of 34 feet and the edge of the roof is at about 17 feet from the floor. The wall is 1 feet thick reinforced concrete. DOE 6430.1A, " General Design Criteria", Section 1307-4.14 requires that for any unproven facility design either a "validated model or full-scale test is required to ensure structural adequacy unless a high degree of confidence can be provided by calculations or other means". It is the authors' opinion that both series of tests described below were in response to this requirement even though it was not in force at the time of 1957 tests.

Summary of Tests

Figure 3 is a sketch of the full scale Gravel Gertie constructed at the Nevada Test Site for the 1957 Gravel Gertie Test. The round rooms for this test bed was constructed as described above except for having 2 feet thick walls. The staging area was designed to have the same free volume as the anticipated operational facilities and is constructed of corrugated culvert with two small concrete rooms.

Table 1 is a summary of all the full scale Gravel Gertie Tests that have been performed. Except for Test 1, which was not of a Gravel Gertie building but of a magazine with a structural roof, and which yielded no good data, all the tests were run in the same round room test bed at NTS.

Table 1. Gravel Gertie Full Scale Test Summary

			Explosive			
Test	**Date**	**Location**	**ID**	**Amt (1b)**	**Tracer**	**Measurement**
1	5/3/56	Pantex	HE	120	500 Ci ^{140}La	Material Spread
2	1957	NTS	TNT	120	None	None
3	1957	NTS	TNT	550	U	Fallout Entrance door open
4	1957	NTS	TNT	550	U	Fallout, Entrance door closed
5	1982	NTS	HE	423	U	Respirable U aerosol release Blast overpressure Gas Pressures

Test 2 used only 120 lb. Of HE and was probably a test of the structure. No tracer was used so no material release data was obtained.

Test 3 was the first in a series of two tests to measure the amount of fallout produced from an explosion inside what is now a standard Gravel Gertie. For this test the entrance door to the staging area was open.

Explosion of the HE-uranium device generated a uranium oxide aerosol, which was the tracer for this experiment. Uranium fallout was measured by means of a large array of fallout trays. Winds before and immediately after the test explosion were measured by tracking released meteorological balloons. The results indicated that the test produced about one-fourth of the fallout that would be produced by the same explosion in the open.

Test 4 was similar in all respects to Test 3, except that the entrance to the staging area of the Gravel Gertie was closed with a blast-proof door. The charge was again 550 lb. TNT with metallic uranium as a surrogate tracer for plutonium. Again, the only measurement made was of uranium fallout by means of fallout trays. After the test the statement was made that no "significant" amount of radioactive material was released.

But these tests measured only fallout.

By 1982 sufficient interest had built up in obtaining some quantitative measurement of the amount of airborne respirable plutonium that would be released from a Gravel Gertie in case of an accidental explosion that it was decided to field an experiment to measure that release.

Test 5 was carried out in the same Gravel Gertie round room that was used for Tests 2,3, and 4. The roof was rehung and a staging area was built that mocked up the volume, but not the exact geometry of staging areas in existence and to be built. The staging area was constructed of 10 feet diameter corrugated steel culvert. Figure 4 is a plan view of the 1962 test facility.

The primary purpose of the test was to measure the ability of the gravel roof to filter respirable particulate matter from the escaping gas as it flowed through. However, measurements were made of blast and pressure histories in several locations in the round room and staging area, and experiments were performed to measure the characteristics of two models of blast valves.

This test used 423 lb of PBX-9404 plastic bonded explosive closely coupled to 8 kg. of uranium metal as a surrogate for plutonium. The particle size and mass concentrations of the uranium oxide aerosol formed inside the Gravel Gertie and in the cloud of material released from the cell were measured by means of air samples, filters, and cascade impactors. Comparison of the two sets of data allowed an estimate of the fraction of material released. Measurements of blast and gas pressures were made. The operating characteristics of two sizes of blast valves were measured. Dr. Wilfred E. Baker measured complete post explosion blast and gas pressure histories at several locations in the round room and staging area. Other test carried out are as listed below.

Sandia National Laboratories Albuquerque managed all the tests and carried out all the measurements except the blast and pressure, which were measured by Southwest Research Institute. The Senior Scientist for Tests 1,2,3 and 4 was M. I. (Bill) Cowan. Robert Luna was Senior Scientist for Test 5.

Methods And Results

The first four tests yielded only knowledge as to the ability of the Gravel Gertie to withstand the forces of the explosion and some fallout data. All information of interest to the present users comes from the measurements made in Test 5. We will go through the more important measurements made and present typical results from each.

1. Aerosol particle size distribution in the cell

   Blast proof samples at four locations in the round room and two locations in the staging area collected a sample of air from the cell and measured particle size cut by flowing the sampled gas through a cascade impactor. Figure 5 is a sketch of the equipment used. Those in the round room

collected the air sample in the period 0-3.5 seconds after the explosion and those in the staging area from 60 to 76 seconds. Figures 6 and 7 show typical results from this measurement.

2. Aerosol particle size distribution outside

A vertical array of cascade impactors was suspended directly above the center of the Gravel Gertie round room. Cascade impactors were suspended on a 6 row by 8-column matrix on a grid suspended under barrage balloons and anchored to three trucks. In this way the grid, which covered a 60^0 in the horizontal direction could be moved so as to be downwind from the Gravel Gertie. A typical particle size distribution of the release aerosol material as measured by three impactors is given in Figure 8.

3. Uranium Amounts

The air samplers and cascade impactors were constructed and operated so as to allow measurement of the mass concentration of the aerosol collected. These data was combined with estimates of air movement inside the cell and with the cloud dimensions outside the cell to obtain a value for the total amount of uranium oxide formed in the cell, and the amount released. Using two values of the fraction of respirable aerosol released: $3x10^{-3} \pm 1.1x10^{-3}$ and $3x10^{-3} \pm 3x10^{-3}$.

4. Blast and Pressure Histories

Sandia National Laboratories made some post explosion pressure measurements, but a thorough set of blast pressure and gas pressure measurements wee made by Dr. Wilfred E. Baker of the Southwest Research Institute. In Figure 4 blast measurements were made at the locations designated B, gas pressures were measured at locations designated G. As you might suspect, the results of these measurements constitute a book. Figures 9 and 10 are examples of a blast and a gas pressure measurement.

5. Roof Travel

Metric movies were taken of the roof rise during the explosion. Figure 11 shows the position of the roof at various times after the explosion. Figure 12 shows a plot of the position of the center of the roof versus time. There were many more measurements made during the tests, mostly in support of those mentioned above. These will not be discussed here; the reader is referred to the Gravel Gertie Report.

Conclusions

The several tests conducted upon the Gravel Gertie showed

- That this design will withstand he forces of an explosion of 423 lb of PBX-9404 or similar HE, and
- That the rising roof will relieve the explosion produced gas pressure from the building in about one second but will allow only 0.3% of the respirable aerosol in the building to escape.

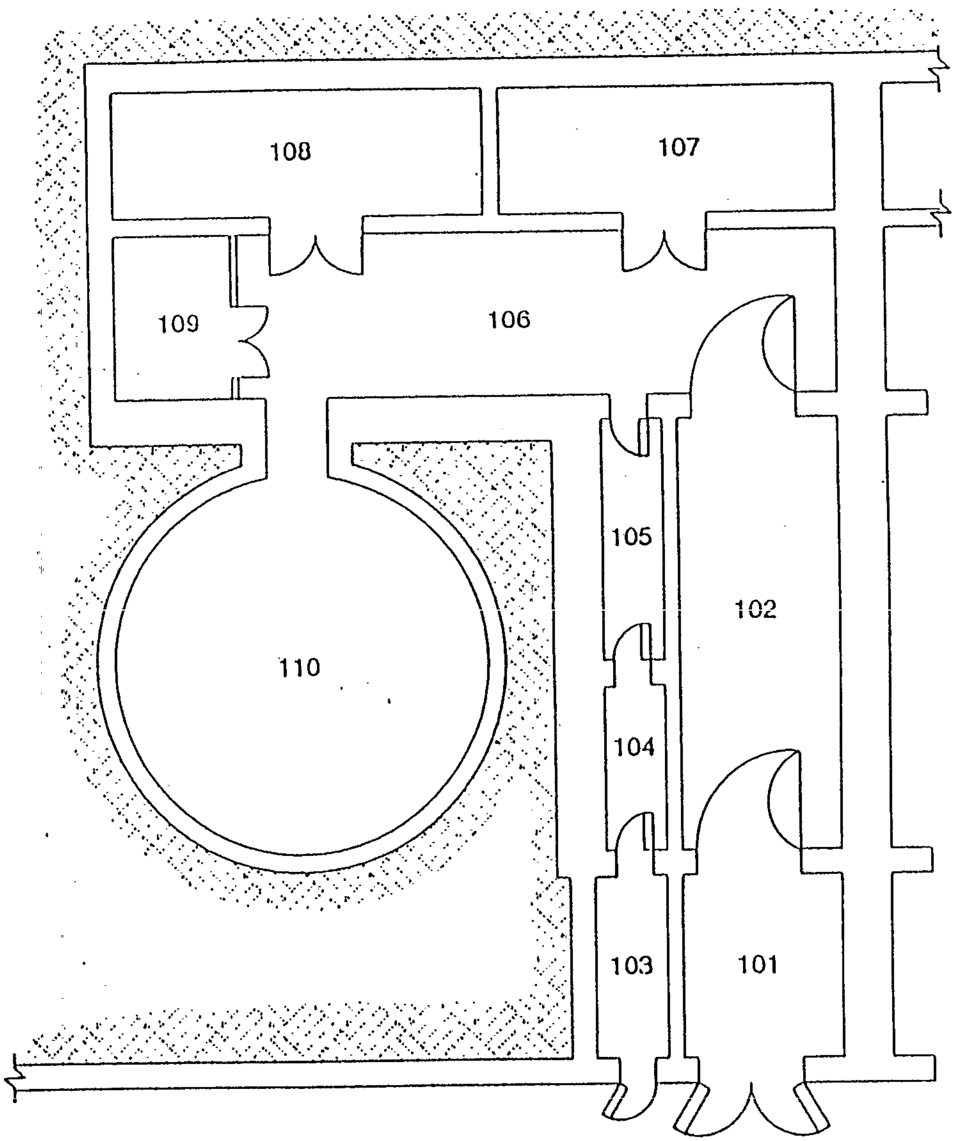
In addition measurements made during the tests provide information as to

- The radioactive material fallout patterns,
- Pressures to be expected within the building from the explosion and
- Size distributions and amounts of uranium aerosol to be expected within the Gravel Gertie and in the cloud of material released from the Gravel Gertie.

The data obtained has been of value to those of us trying to estimate accident consequences for more than 14 years. It seems safe to say that this was a highly successful experiment.

Building 301, 302, 303, 304, and 305, Assembly Cell

101	Equipment vestibule
102	Equipment airlock
103	Personnel vestibule
104	Personnel airlock
105	Personnel corridor
106	Corridor
107	Mechanical room
108	Tool staging
109	Inert parts staging
110	Assembly room



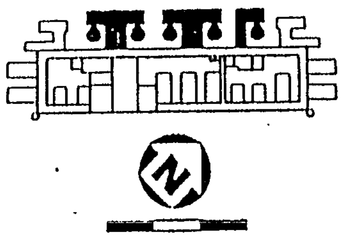


Figure 1. Plan of DAF Gravel Gertie

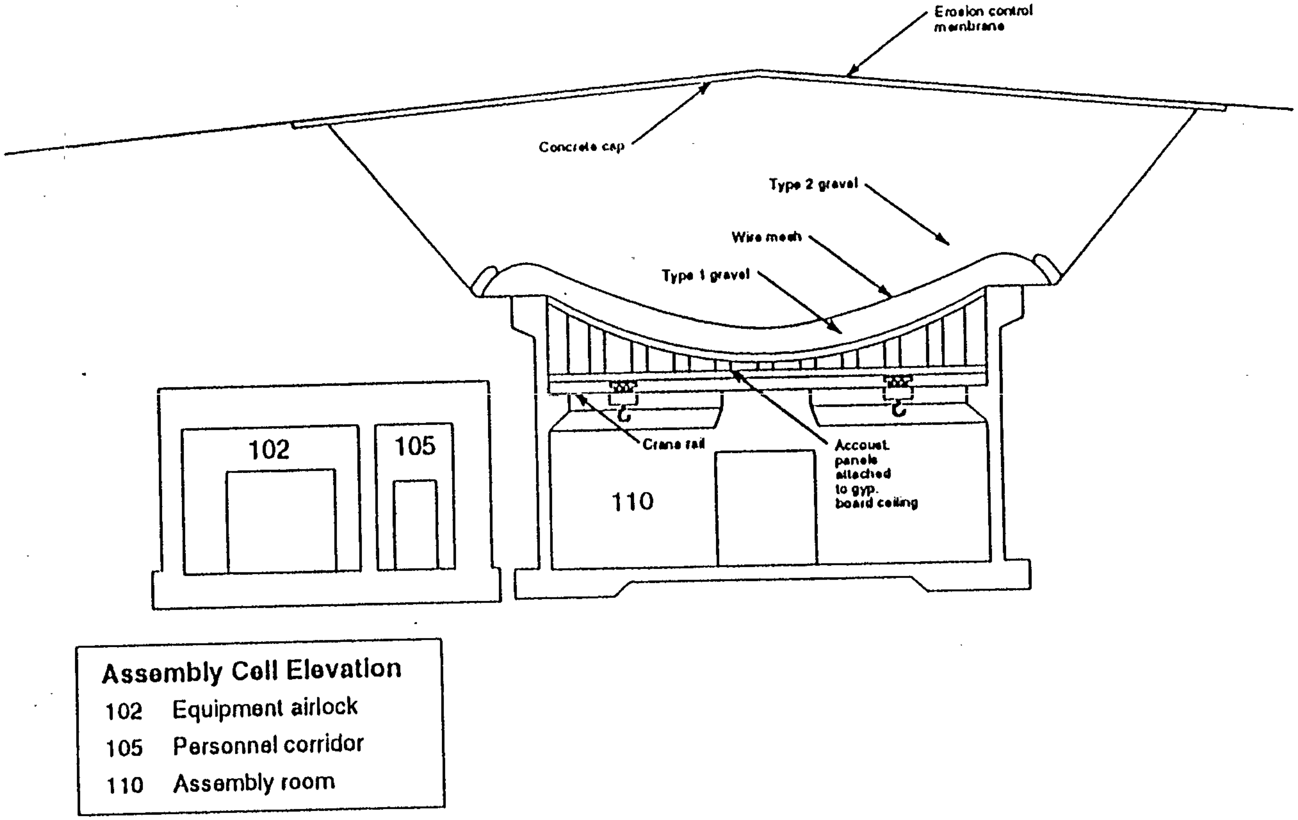


Figure 2. Gravel Gertie Elevation

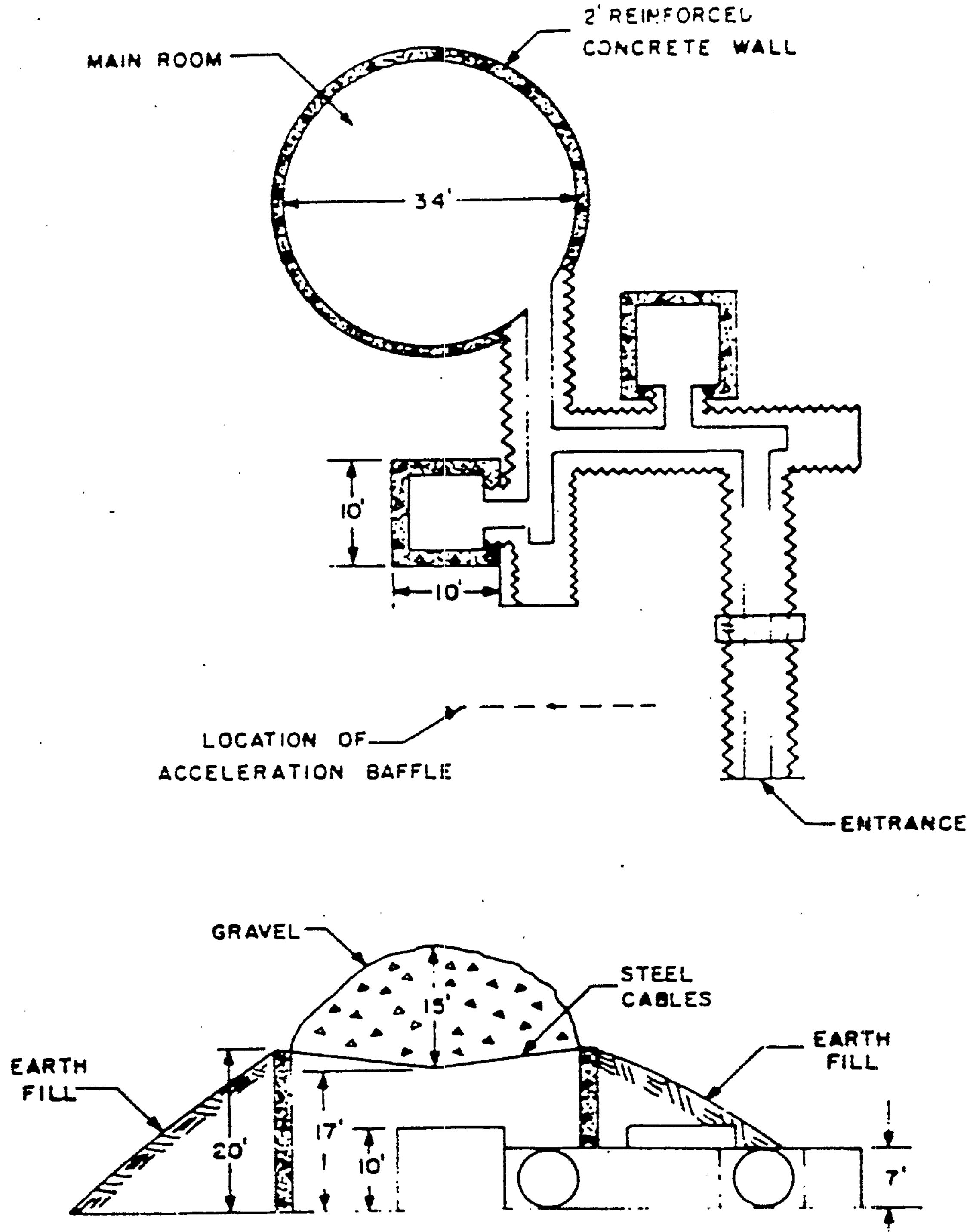


Figure 3. 1957 Gravel Gertie Test Structure

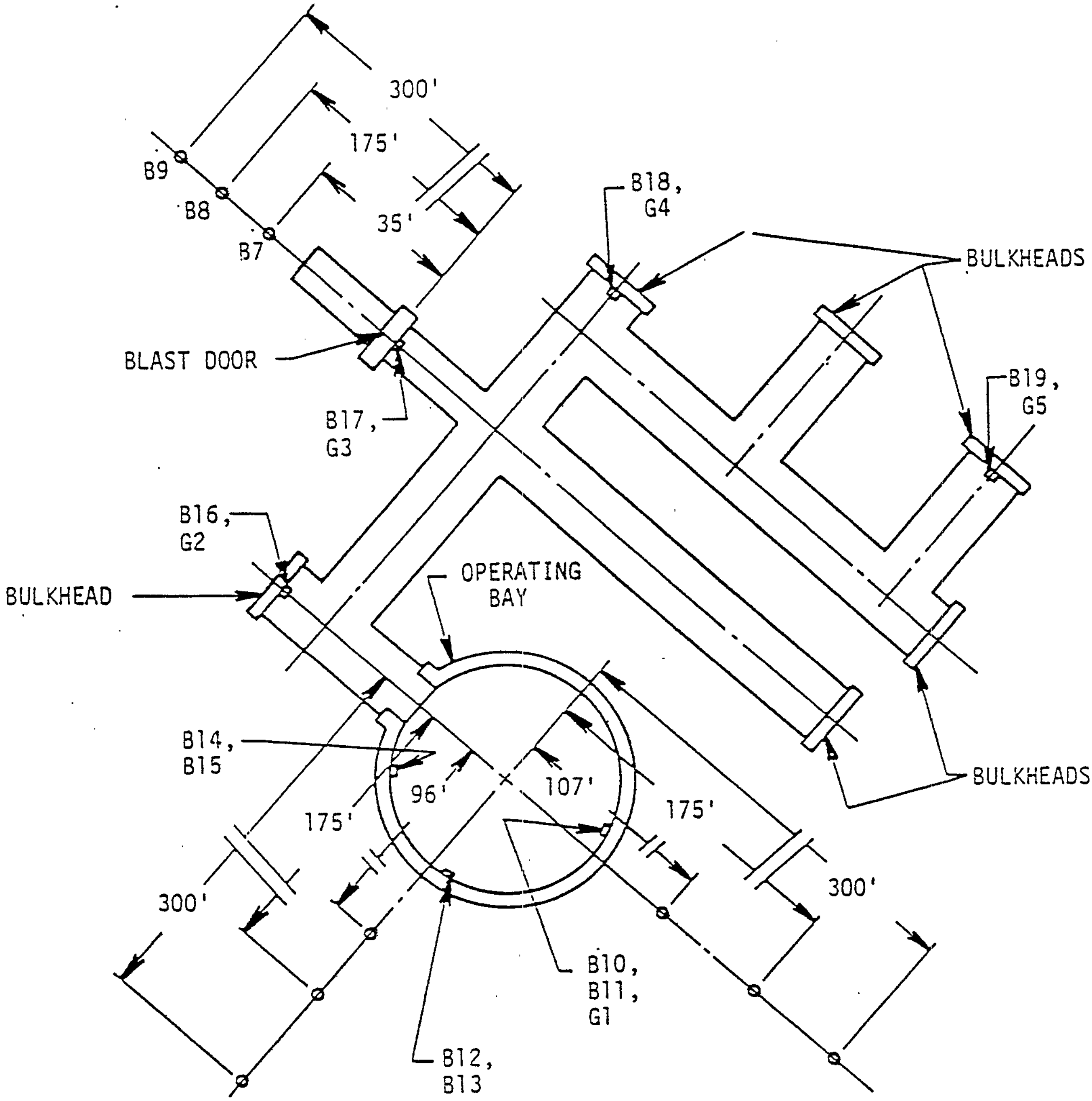


Figure 4. 1962 Gravel Gertie Test Structure with Transducer Locations

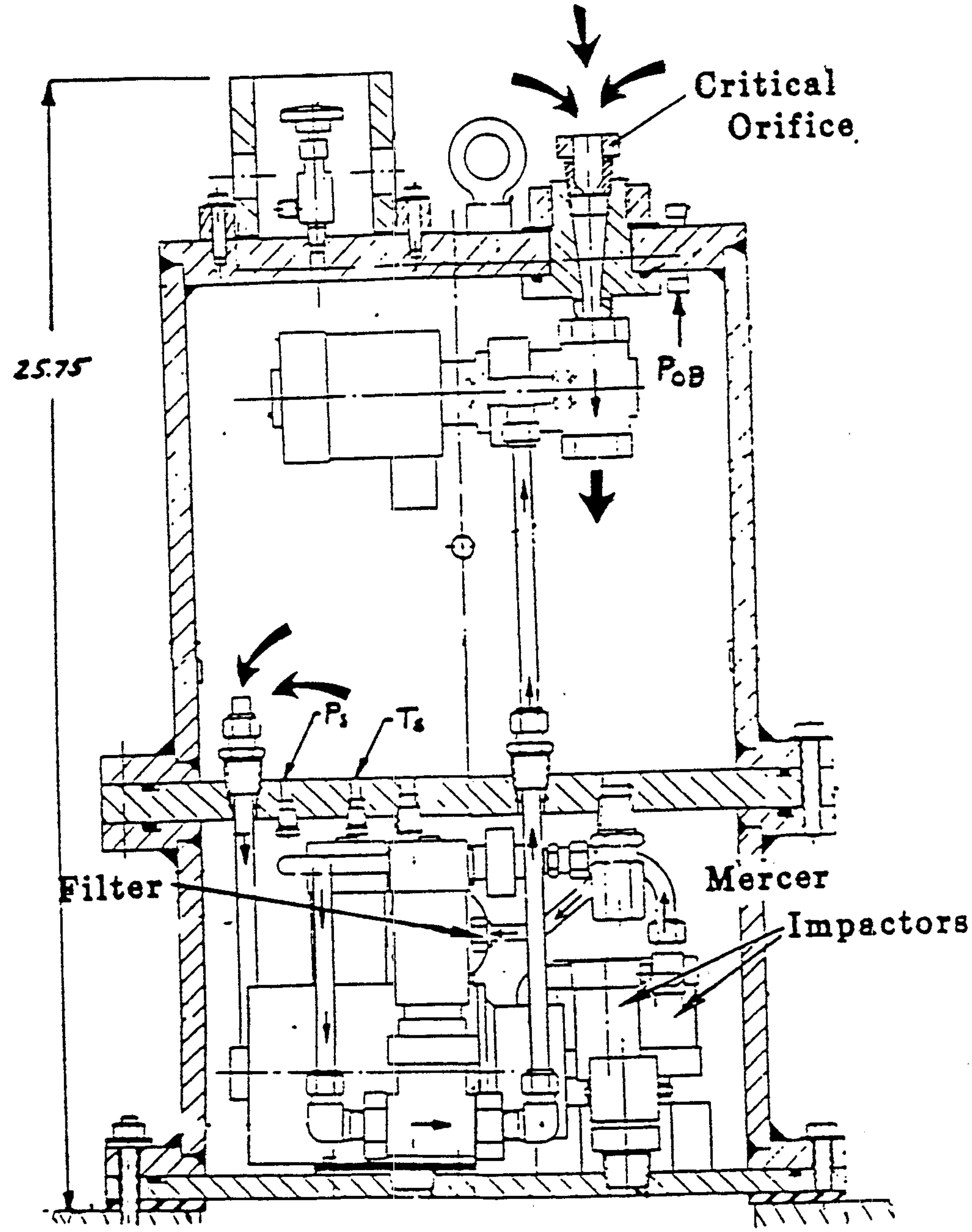


Figure 5. Blast Proof Air Sampler and Cascade Impactor

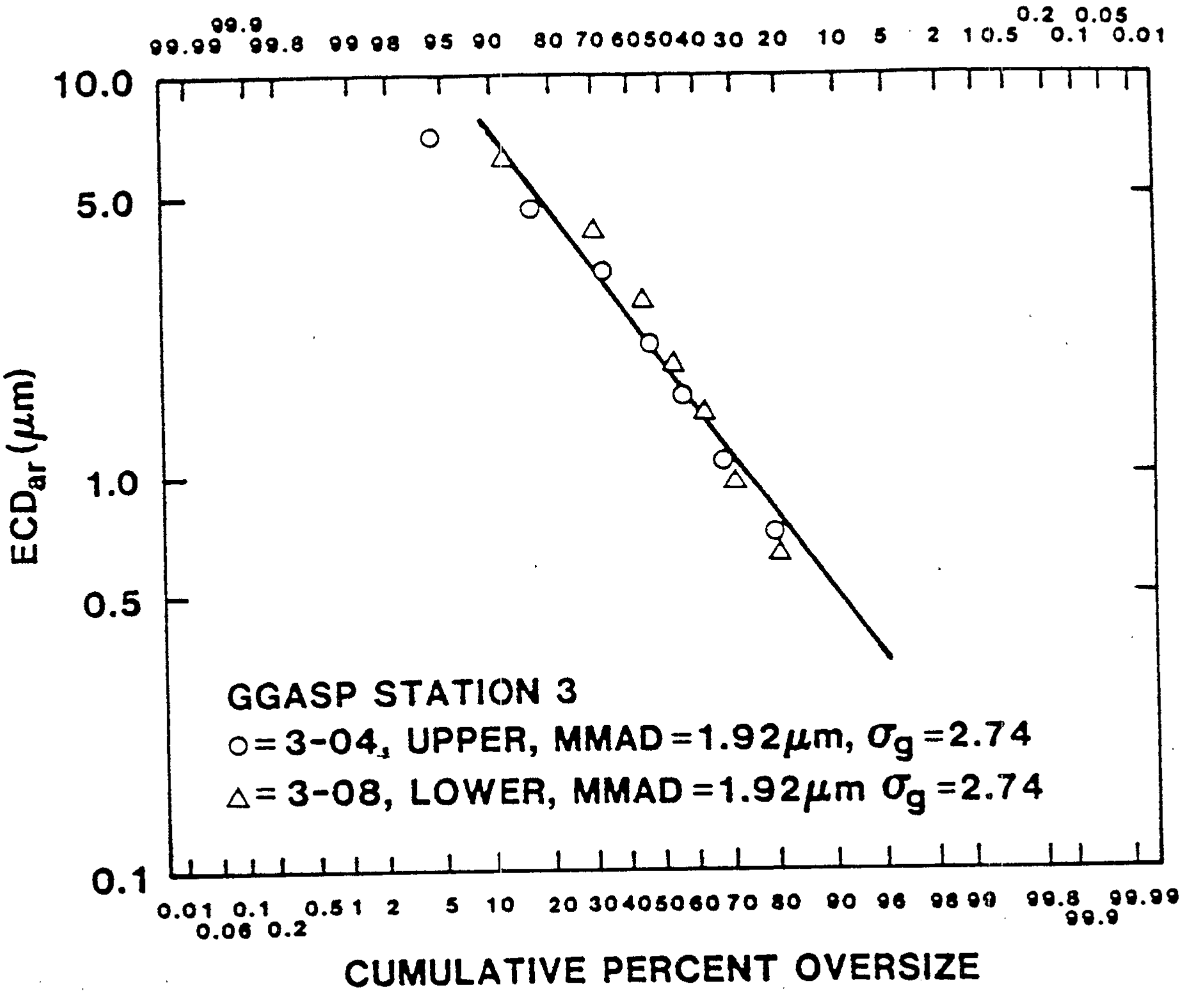


Figure 6. A Log-Normal Fit to Cascade Impactor Data in Round Room Showing Effective Cutoff Diameter as a Function of Cumulative Percent of Mass Oversize

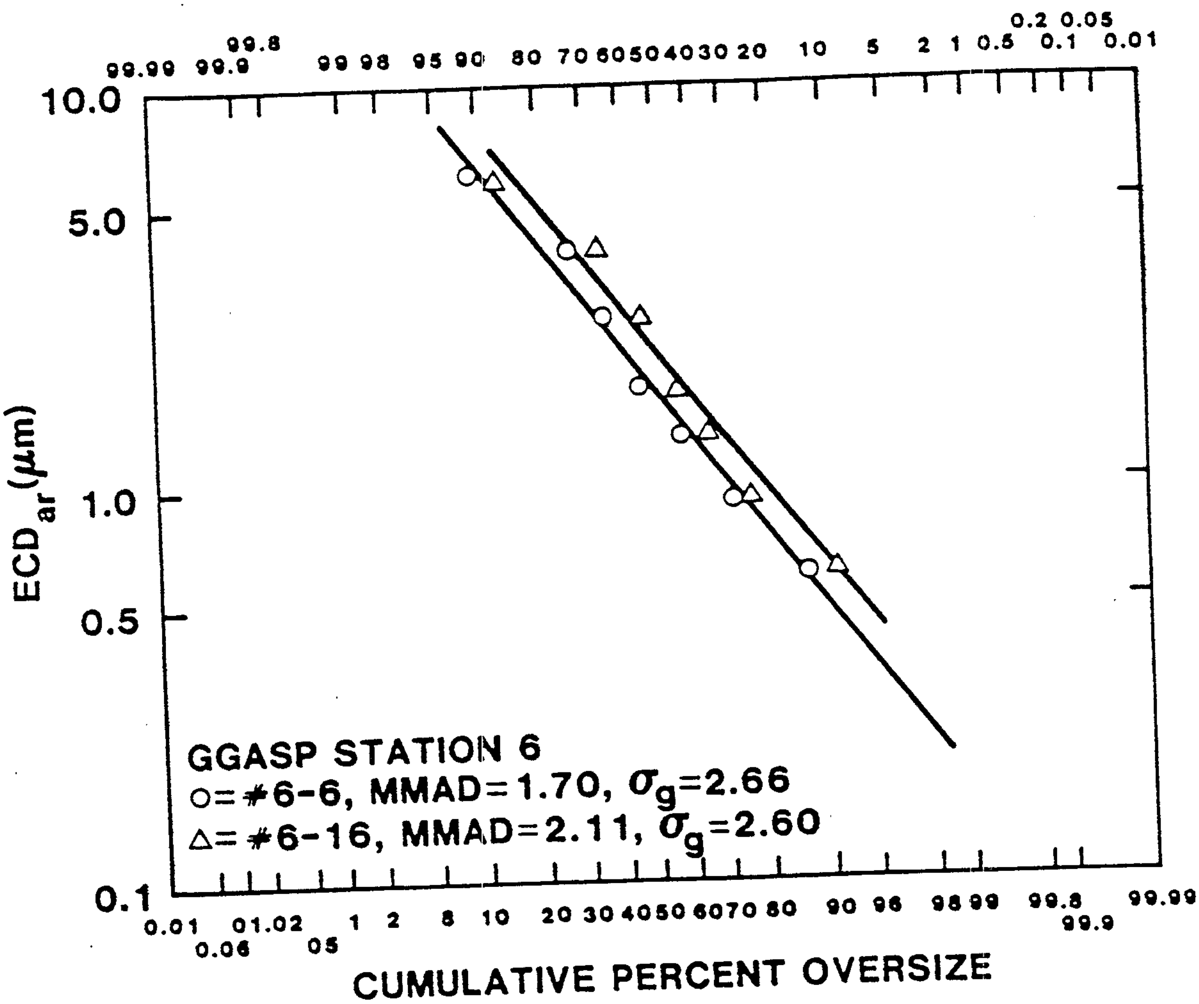


Figure 7. A Log-Normal Fit to Cascade Impactor Data at Far End of Staging Area showing effective Cutoff Diameter as a Function of Cumulative Percent of Mass Oversize

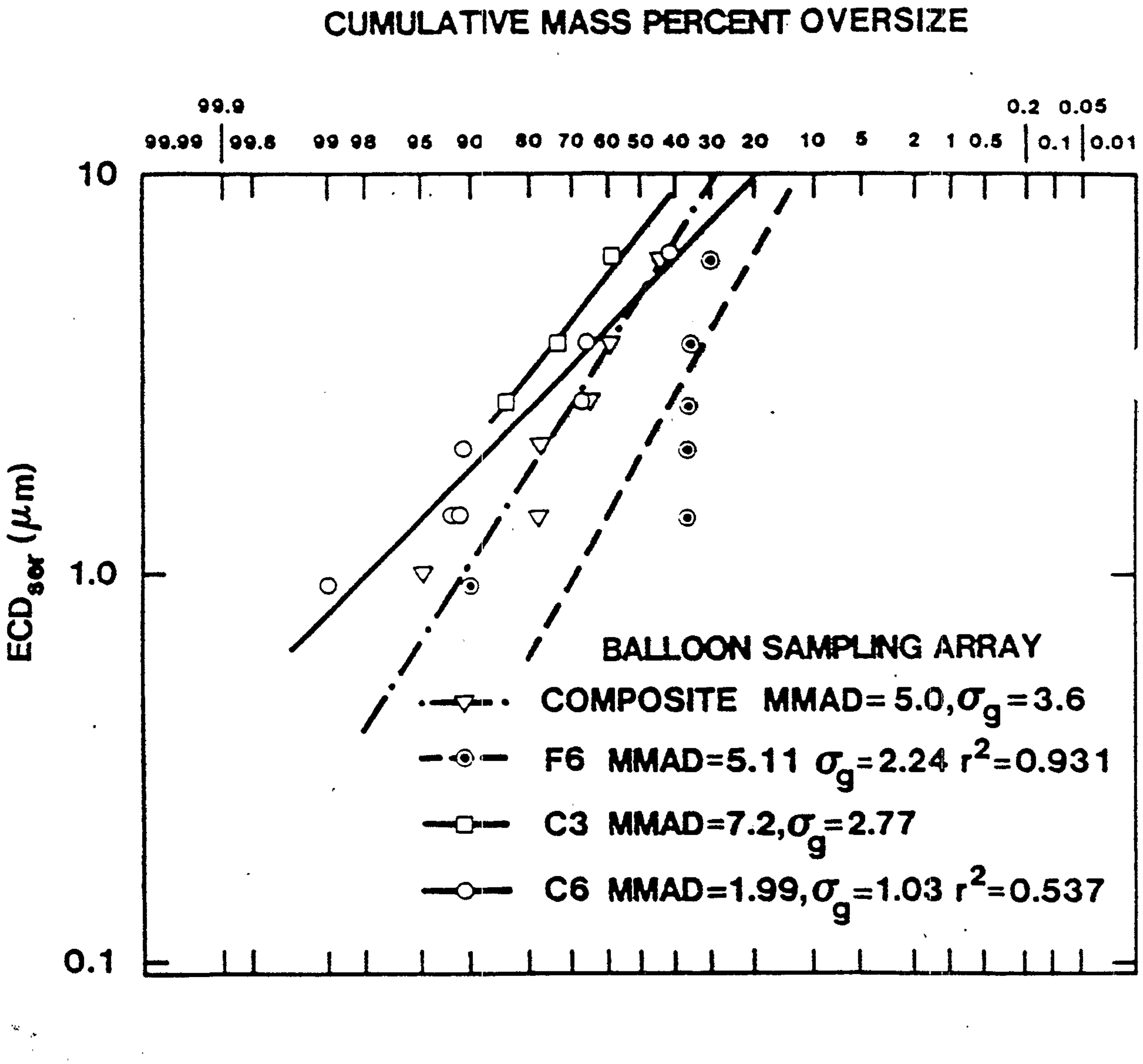


Figure 8. Size Distribution at Three Locations in Cloud of Released Material

Figure 9. Blast Pressure in the Gravel Gertie Round Room

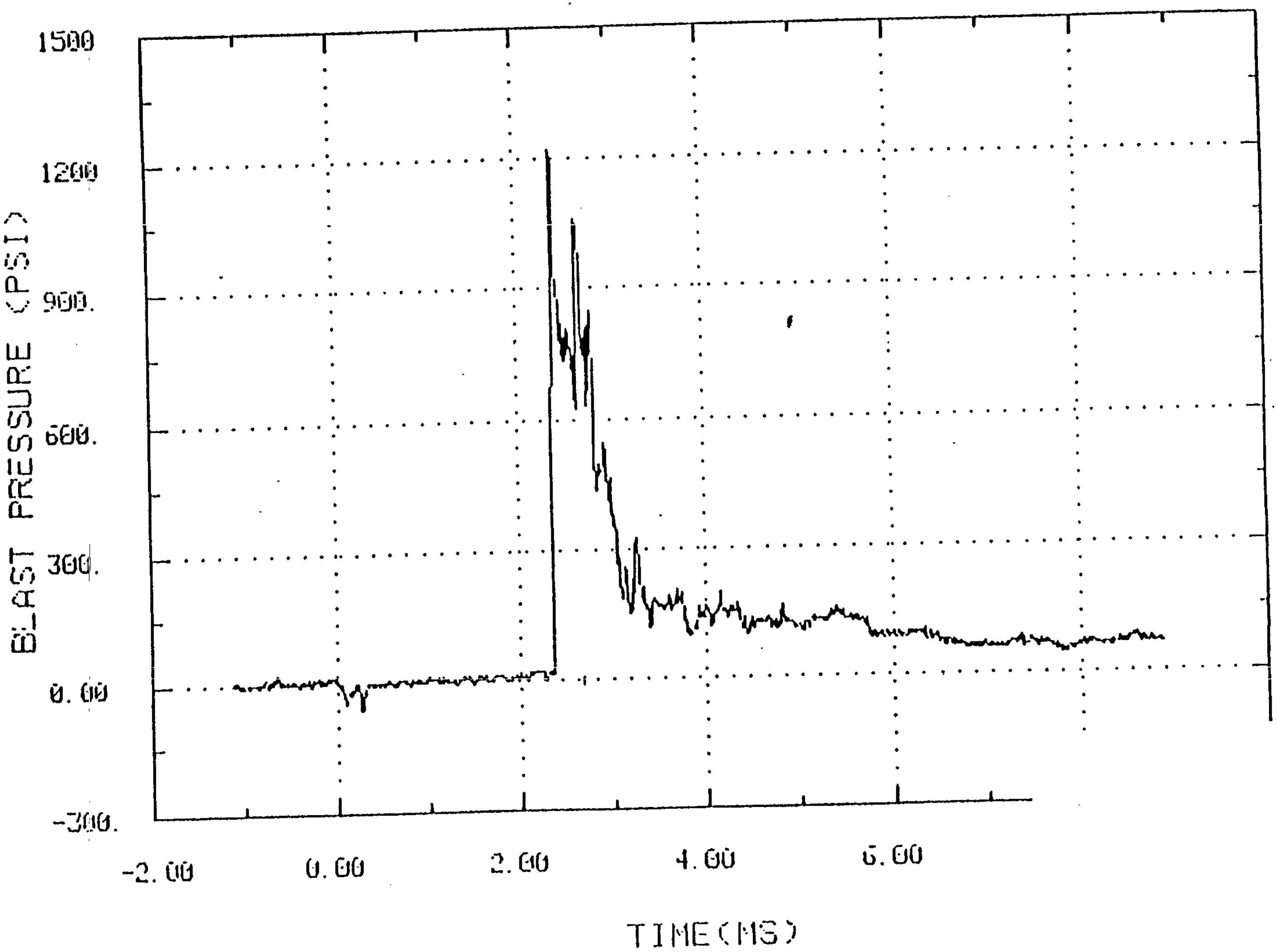
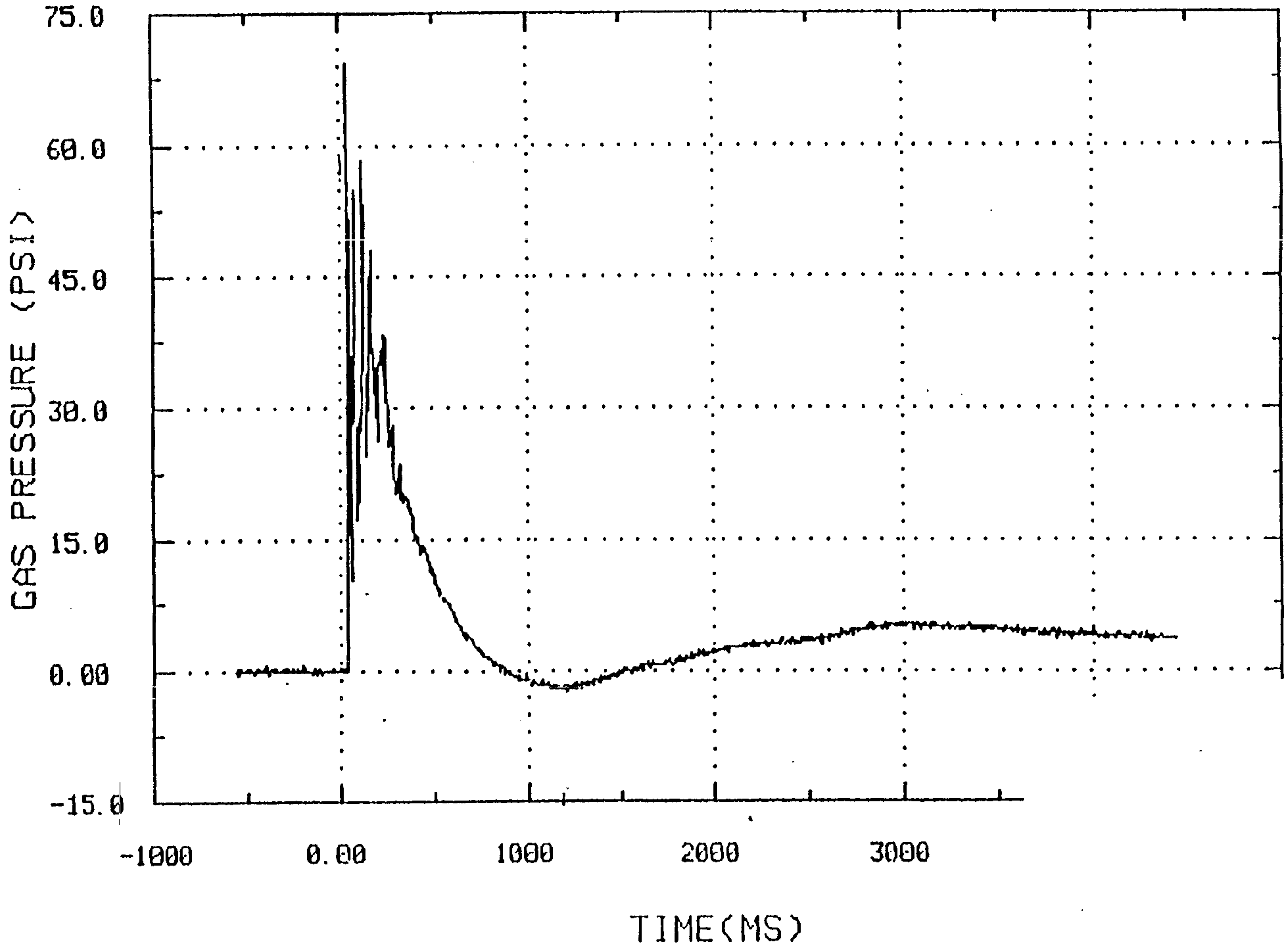


Figure 10. Gas Pressure in the Gravel Gertie Staging Area



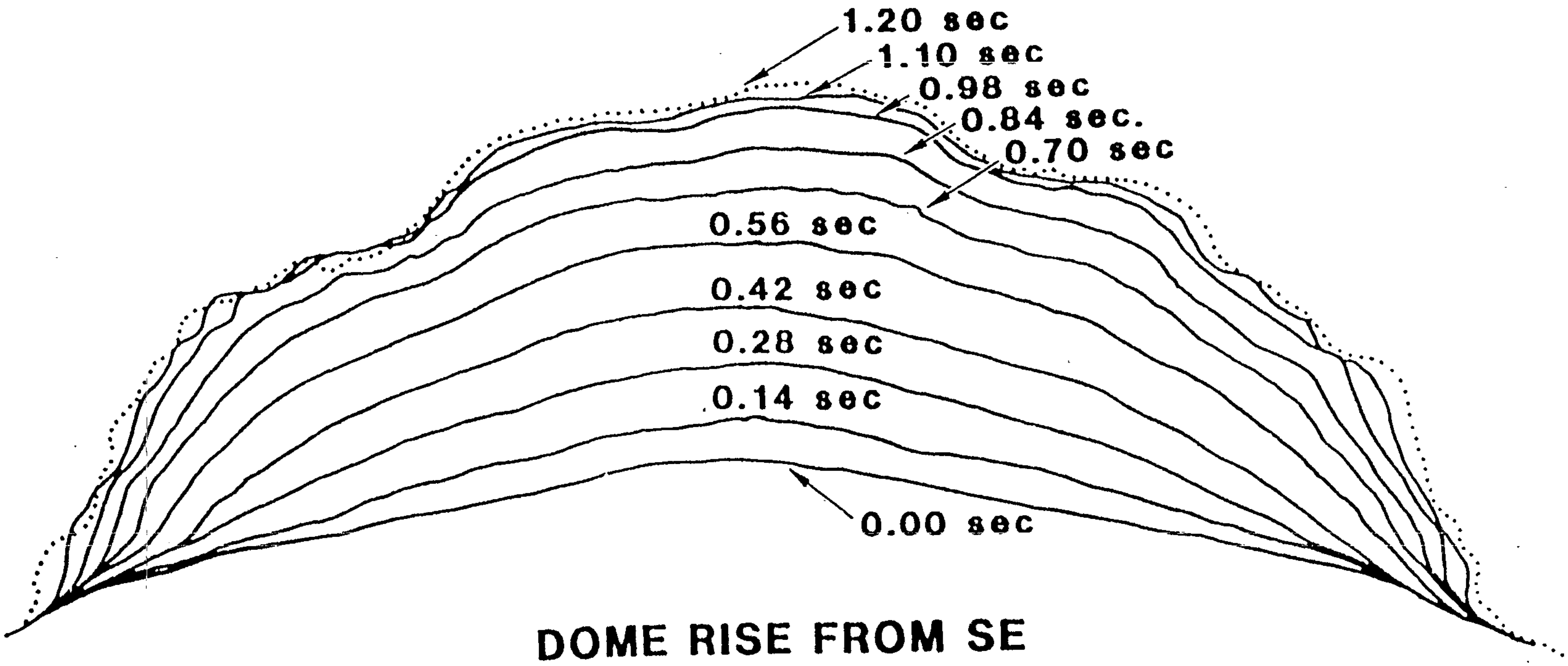


Figure 11. Gravel Bed Profiles during Dome Rise

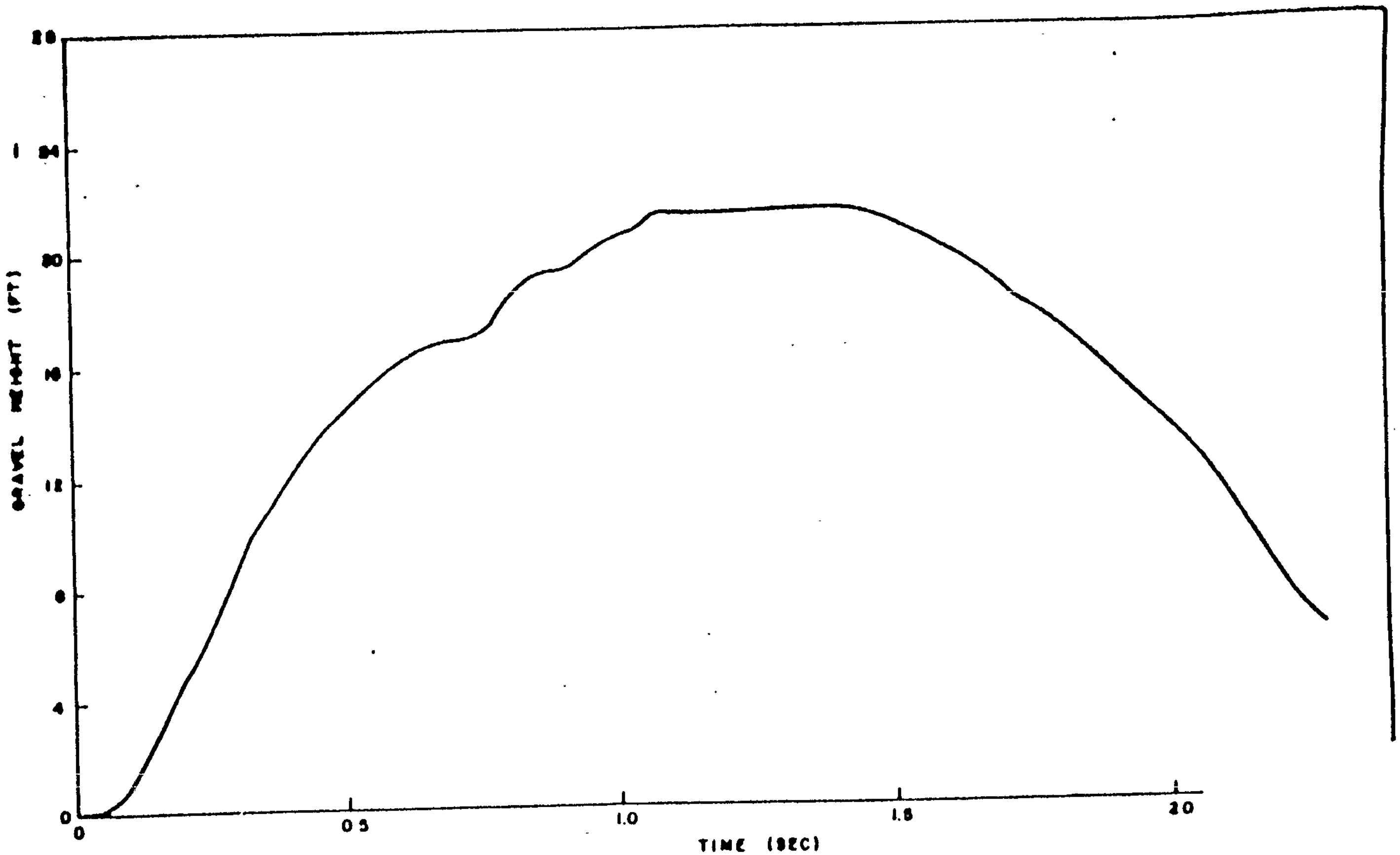


Figure 12. Gravel HeightVersus Time (1957 Test)